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The Reservoir for snow-drifting from Poiana Braşov

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Abstract - One of the objectives of the developing and rehabilitation of the skiing area in the Poiana Braşov resort is represented by the reservoir for snow-dr ifting in Poiana Ruia. This reservoir is bordered by the mountainside upstream and by a quasi-circular embankment dam downstream. The lake is sealed both on the bottom and on the gradients with several layers of clay, geo-textile, gravel and high-density plastic sheet. The water taken from the mentioned lake is pumped to the artificial snow producing devices. The natural conditions of the reservoir imposed the design solutions presented in this paper.

Keywords: dam, sealing coat, Poiana Ruia reservoir, spillway

1. INTRODUCTION

Braşov county has an approximate percent of 7, 5% of the total functional tourist accommodation capacities in Romania, being on the second position from this point of view.

A significant part of these tourist accommodation places is in the Poiana Brasov resort, situated about 12 km south-west from Braşov.

The skiing season in Poiana Braşov, which detains a surface of about 51 hectares for the practicing of this sports, starts on the 15th of November and ends on the 30th of March, when a number of around 11.000 tourists were present. Throughout the skiing season, there was an average number of 1500 – 2000 daily tourists in the skiing area.

The fame that Poiana Braşov has gained in the last 60 years, the increasing number of tourists that visit it has imposed the drawing up of an extension and rehabilitation project of the current skiing area, which is part of an ample modernization program of the resort. This project contains extension works of some already existent tracks, the building up of new tracks and access roads, track draining, setting up new cable transportation means, placing new devices for artificial snow production, parking lots placements, etc.

The general designer of this fitting out is S.C.PRINFO S.R.L. from Braşov.

One of the main objectives of this project is represented by the snow-drifting reservoir in Poiana Ruia, situated in the south of the habitable area of the Poiana Braşov resort, on the northern mountainside of the Postavarul Mountain.

The specialty designer of the reservoir is Klenkhart & Partner Consulting ZN GmbH from Absam, Austria.

2. SITE CONDITIONS

The site of the reservoir is between the 1475,00 m.. and 1500 m. heights, at about 1,5 kilometers, at the highest slope from the habitable area of the Poiana Braşov resort.

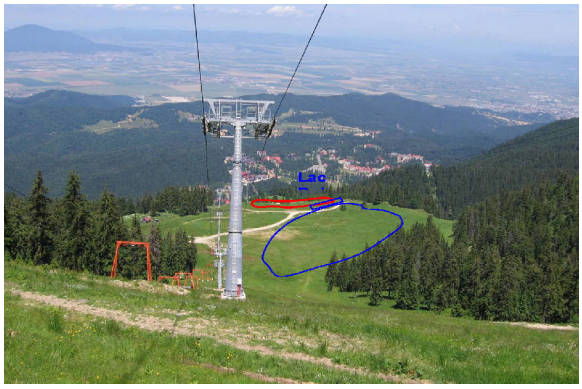

Fig. 1 The site of the future Poiana Ruia reservoir

The water flows for the future reservoir are drawn from the nearby springs, from the existent drains which collect the phreatic water, and partially, from the water supply system for the existent tourism objectives in the Postavarul Mountain.

The amount of the previously enumerated flows is estimated at 14 l/s .

The hydrologic studies done by Hydrologic Plant of S.G.A. Braşov indicate that the springs situated in the area of the future reservoir could provide a minimal flow covering 80% of necessities, of 5,62 l/s.

Also, from the same studies results that the drains that will be rehabilitated could collect a flow covering 80% of necessities, of 8,00 l/s.

From a geologic point of view, Cretaceous age-old basic rock is represented by marls and diorite calcareous sand, respectively limestones, conglomerates and gritstones. Frequently, there are Jurassic age-old calcareous rocks.

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In the site area, the development of important karst phenomena hasn't been signaled.

The base rocks are covered by Quaternary deposits of clay deluvium (dusty – sandy) with rock fragments.

The geotechnical studies elaborated by GEOSOND Bucharest and NEOLITOS S.R.L. Braşov have highlighted the following stratifications:

a) in the upstream area (southern) of the reservoir site, the area of the versant excavated and of the lake's water supply

0 – 0,30 m vegetal soil;

0,30 – 3,20 m sandy argyles with dusty areas;

3,20 – 14,00 m fragments of calcareous rocks caught in the argyle mass;

14,00 – 15,00 m cracked and altered limestones.

b) In the central reservoir area:

0 – 0,30 m vegetal soil;

0,30 – 2,20 m brown-yellowish argyles;

2,20 – 11,60 m fragments of calcareous rocks caught in the argyle mass;

11,60 – 15,00 m cracked and altered limestones.

c) In the northern area of the reservoir site (the area of the maximal cross-section of the dam and pumping plant):

0 – 0,30 m vegetal soil;

0,30 – 11,50 m fragments of calcareous rocks caught in the argyle mass;

11,50 – 15,00 m cracked and altered limestones.

The previously mentioned studies demonstrated that, depending on the composition of the covering layer and on its spatial relationship to the base rock, the geological structure does not present the risk of soil slidings. Yet, they can be initiated in case of excavations deeper than 5 m, with abrupt slopes and provided adequate steps are not taken.

Although the litho-static conditions are favorable for the future reservoir so that the geologic equilibrium of the mountain is not broken, in the geotechnical studies it is emphasized that possible water leakages through the dam or through its foundation could trigger downstream land destabilizations, especially in its sharp slopes areas.

From a hydro-geologic point of view, in the area of the future reservoir the presence of small aquiferous deposits has been signaled as well as small springs supplied by free surface flow without any special importance for the concerned site.

The geologic prospects highlighted the presence of underground water in the central area of the future lake, at a depth of 4,0 m, the hydro-static (ascendant) level being established by drilling at the depth of 2,00 m.

The studies indicated a permeability coefficient of 10^{-4} cm/s for clay deluvium deluges and of 10^{-1} cm/s for till (rocky calcareous fragments caught in the argyle mass).

From the point of view of the area's seismic character, according to the normative P100-1/2006, the acceleration of the land for design is 0,20 g and the peak period is of 0,7 s.

3. POIANA RUIA SNOW – DRIFTING RESERVOIR AND THE ADJACENT BUILDING WORKS

The water necessary for the snow-drifting of the 60 hectares of existing and developing tracks from Poiana Brasov was estimated to 145000 m^3. Starting from the premise that a part of the necessary water volume can be assured from the Poiana Brasov water supply network, Poiana Ruia's reservoir capacity resulted to be of 120000 m^3.

Taking into account the topographic conditions and the access to the site as well as of a reasonable rapport between the volume of excavations and filling-ins, a semi-embankment reservoir was projected (fig.2).

The characteristics of Poiana Ruia's reservoir are:

- Maximum storage volume: 122500 m^3;
- Maximum reservoir surface: 1,58 ha;
- Retention water level: 1496,00;
- Maximal height of embankments: 13,00 m;
- Maximal depth of excavations: 13,00 m.

The water flows collected by drains and by existent drilled wells upstream the reservoir are accumulated in a collecting basin meant to have two compartments, placed in the area where the lake is bordered by natural land.

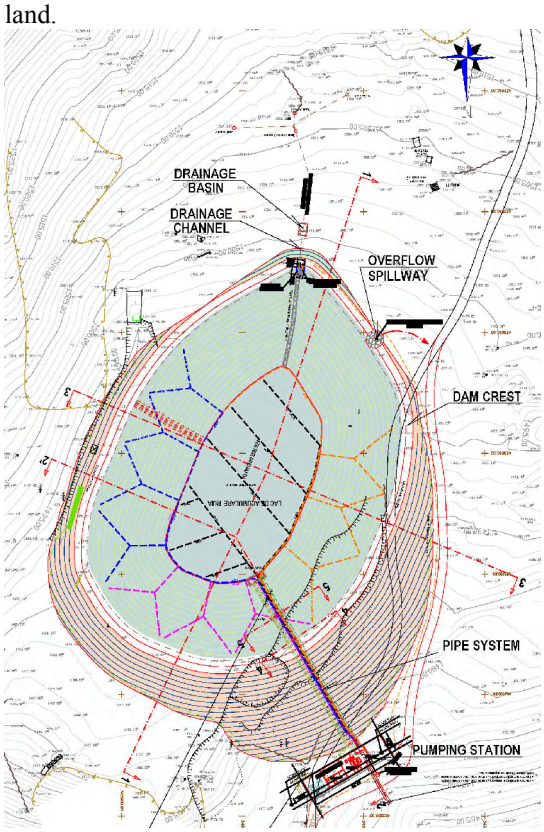

Fig.2. A plan view of the Poiana Ruia reservoir

From the first compartment, the water is gravitationally transported into the lake by a gutter situated on the excavated gradient of the lake.

The second compartment fulfills the function of overflow for a safe exploitation of the reservoir. From this compartment, in the extreme case of malfunctioning of the automation which controls the cease of the water supply to the lake when the level of the water in the reservoir is beyond the retention water level, the water is evacuated by a ND 200 mm pipe upstream the reservoir.

The water flows necessary to the production of the artificial snow are taken from the bottom of the lake by a bottom intake and transported by two pipes ND 400 mm to a pumping plant situated downstream the reservoir near the downstream toe of dam.

These pipes are part of a pipe system placed in a ditch under the foundation of the dam, in the foundation rock.

The pipes are placed in layers on two levels. On the inferior level, there are 4 ND 150 mm pipes by which the drained flows are exhausted and on the superior level, there are 10 pipes (with diameters between 80 and 400 mm) with different functions.

All pipes are embedded in concrete in the already-mentioned ditch which has a length of 81,00 m.

In order to avoid the lateral movement of the pipes, at about its middle a concrete diaphragm with a width of 7,00 m and a height of 3,00 m has been designed.

The pumping plant, which is placed at the downstream toe of dam that borders the reservoir, is equipped with:

- A group of 3 automatized parallel-connected pumps, Q min = 50 l/s and Hp = 500 m, which assures the necessary water for the snow-drifting of the skiing area;
- A clearing pump in case of damage or for the lake's cleaning period.

The reservoir is sealed both on the bottom and on the slopes by several strata of clay, geo-textile, gravel and high-density plastic sheet. presented in Figures 3 and 4.

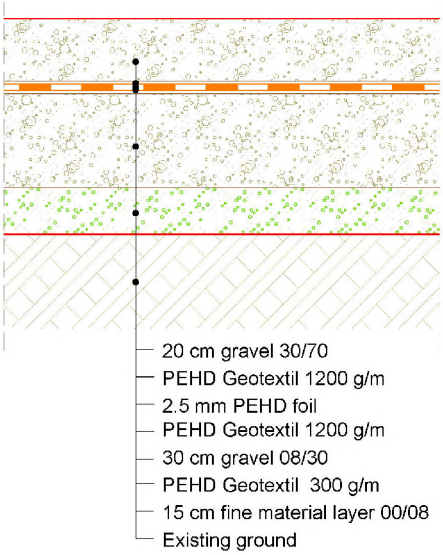

Fig. 3. Sealing coat of the lake's bottom

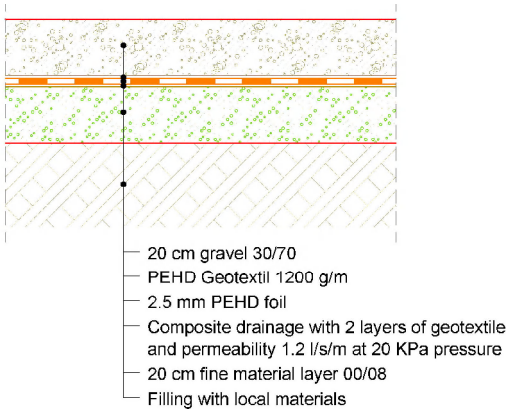

Fig. 4. Sealing coat of the lake's slopes

4. THE DAM OF THE POIANA RUIA RESERVOIR

The dam falls into the category of importance 3 according to the STAS 4273-83 (the height of the dam 10m<H<25m) and the importance class III.

According to 'The methodology for the establishment of dams' importance categories – NTLH – 021', the dam of the Poiana Ruia reservoir falls into the importance category C from the point of view of the associated risk (dam of a normal importance).

The dam's site has a general slope of around 5% in the south-west – north-east direction. The configuration of the site presents no danger of avalanches or torrents.

The dam, which will be built with local materials, has the following characteristics:

- The maximum height of the dam (in axis): 13,00 m;
- The elevation of the top of dam: 1497 m.d.M;
- The top width : 3,00 m;
- The slopes :
  Interior: 1:2,3
  Exterior: 1: 2,0;
- The length of the dam: 470 m;
- The dam's volume: 58.800 m^3.

On the establishment of the freeboard of 1,00 m the height of the possible waves in the lake was taken into consideration.

The foundation of the dam is a compact till.

The water slope face of the dam will be sealed with the same sealing coat as the one used for the sealing of the lake's slopes (fig.4).

In figure 5, a cross-section of the dam and pumping plant is presented.

The surface of the hydro-graphic basin from which free surface flow concentrates in the section of the lake is of about 0,16 km^2. For the collection of these surface flows, a drainage channel situated upstream a dike which borders the reservoir upstream and does not allow the flowing of the water from the versant into the lake has been designed. The drainage channel conducts the water flows collected to the western and eastern sides of the lake. Under the already-mentioned drainage channel, there is a drain which collects the phreatic water from the versant.

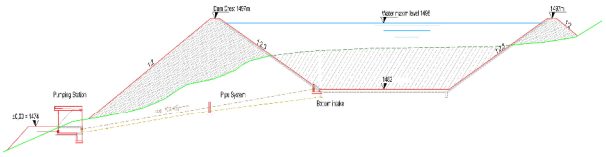

Fig. 5. Cross-section of the dam and pumping plant

Besides the sealing coat draining, throughout the entire watered surface of the lake's slope a Y-shaped drain network has been designed discharging in collecting pipes situated at the toe of the slope, which, at their turn, discharge in the pipe network which connects the bottom of the reservoir to the pumping station.

At the toe of the exterior slope there is a piped drain with a 150 mm diameter.

For the exceptional situation when the drainage channel situated upstream the lake cannot entirely collect free surface flows from the versants, a free overflow spillway has been designed. It will be situated on the south-western border of the reservoir in the area where the elevation of the natural land corresponds to the one of the dam's top (at the south-western extremity of the dam) where the excavated border of the lake begins.

The elevation of the top spillway's is 1496,20, with 0,80 m under the elevation of the top of dam.

The flows collected by drainage channel as well as the possible flows which pass through the overflow of the basin's water supply collector and through free overflow spillway are exhausted in a controlled way downstream the Poiana Ruia reservoir.

The Poiana Ruia reservoir is endowed with monitoring equipment (topographic reference points, hydro-metric pole, digital devices for the measurement of the water's level in the lake, of its temperature and a flow-meter for the measurement of possible leakage through of the sealing coat).

5. CONCLUSIONS OF THE PROJECT OF THE POIANA RUIA'S RESERVOIR AND RECOMMENDATIONS CONCERNING THE FOLLOWING DESIGN STAGES AND ITS WORKS

The project referring to the Poiana Ruia's reservoir is at the feasibility study stage and represents a premiere in Romania in as far as the purpose for which the reservoir will be built is concerned.

The analysis of this project by experts of the Ministry of Woods and Environment and the evaluation documentation of the operation safety state of dam by the National Dam Safety Commission pointed the following conclusions and recommendations.

a. The calculation hypothesis taken into consideration by the specialty designer in the calculations of the dam's stability has led to the use of some values higher than the internal friction angle than the ones which resulted from the geo-technical studies. In this sense, the recalculation has been recommended.
b. Taking into consideration that the presence of aquiferous water has been signaled in the versant, the hypothesis of the unfavorable exterior hydrostatic pressure on the lake's sealing coat upstream the reservoir, of the excavated border has been released. Bearing in mind that the presence of the aquiferous water has been identified in only one drilling, the field studies will be deepened and the specialty designer will offer a solution for the draining of this area where the excavations have a depth of about 9 m.
c. Another remark which must be solved in the future is the one of the possible shearing of the sealing plastic sheet at the contact between the dam and the excavated area of the lake due to irregular settlement.
d. The checking of the entire stability of the versant is a necessity in the conditions of the reservoir's construction.
e. During the works of excavations, the recommendations of geotechnical studies concerning the slops and berms will be paid attention to.
f. When dam will be built, great attention will be paid so that the foundation is done in horizontal plans by covering the level differences by means of joining steps and the filling-in should take into consideration the results (concerning the number of compaction devices goings, the thickness of the strata, lay humidity, etc.) obtained on an experimental pitch.
g. At the execution of the bottom intake a special attention will be paid to sealing in order to avoid water infiltration along the concrete ditch where the pipes which connect the lake to the pumping plant are placed.

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